WBS 1.6
Calorimeter Electronics

E.J. Mannel

29-Nov-2016

PMG Homework

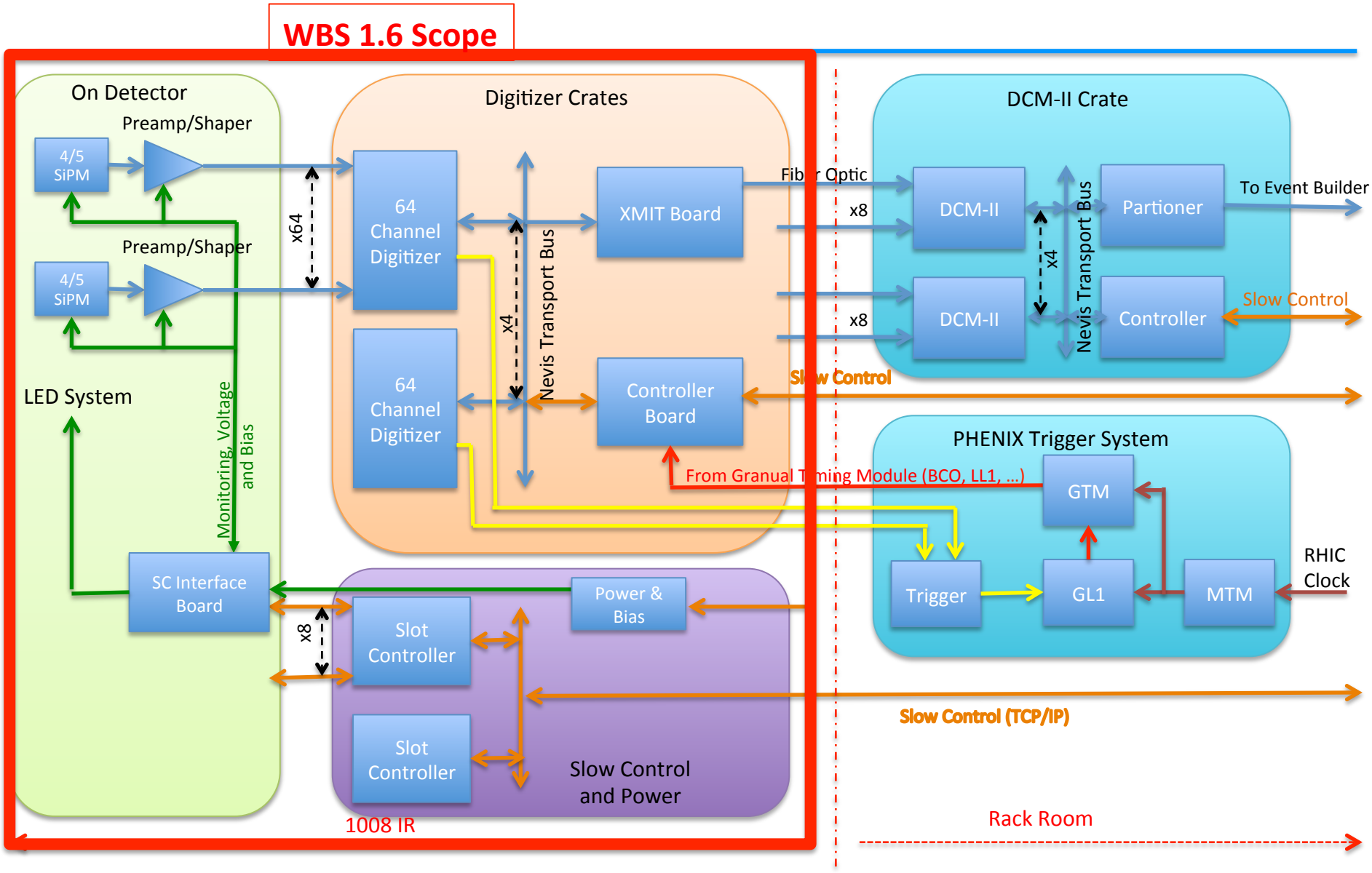
November 8, 2016 sPHENIX PMG
Action Items for Follow Up

1. A detailed overall project roadmap/timeline/milestones for arriving at a June CD-1 review for all elements of the plan: cost, schedule, risk, documents, reviews, etc.
    a. The PMG would like to see as part of this the plans to draft, finalize, review and sign off on the required CD-1 documents, including lead authors for each, and when a draft for each can be expected that can be reviewed.
    b. A list of principals preparing the plan in each Level 2 system, and the fraction of their time they are able to devote to it over the next 8-10 months.
2. The presentation of a single Level 2 system, of your choice, by that Level 2 Manager. This should address all of the below in whatever detail is available at that time:
    a. Technical design and scope
    b. Design specifications and interfaces
    c. WBS structure and management
    d. WBS dictionaries
    e. Current cost estimate, including profile and contingency
    f. Schedule and milestones
    g. Risk analysis
    h. A detailed roadmap/timeline/milestones for readying this system for a June CD-1 review, and who will be working on which portions of it at what fraction of their time.
3. Please compile a few page document detailing the goals for the upcoming test beam program. This should include a list of the metrics that will define whether the goals have been achieved. The PMG would like to receive a draft of this on December 1.

A) Technical Design and Scope

- Optical Sensors:
  - Reference Design: SiPMs, 3x3 mm^2, 44K Pixels per device
- Front End Analog Electronics:
  - Amplifier/Shaper/Driver Circuits for EMCal & HCal
  - Slow Control for EMCal/HCal
  - LED Based Testing/Calibration for EMCal/HCal
  - Designed at BNL
- Back End Digital Electronics:
  - Waveform digitization for EMCal/HCal
  - Transmission to sPHENIX DCM-II
  - Designed at Columbia University/Nevis Labs
- Power & Cabling:
  - Power for Analog/Digital Sections
  - Power and Signal (optical/copper) Cables.
- Q/A Testing and Reviews At All Stages
- No significant changes in past 2 years

Calorimeter Electronics Overview and Interfaces



B) Design Specifications

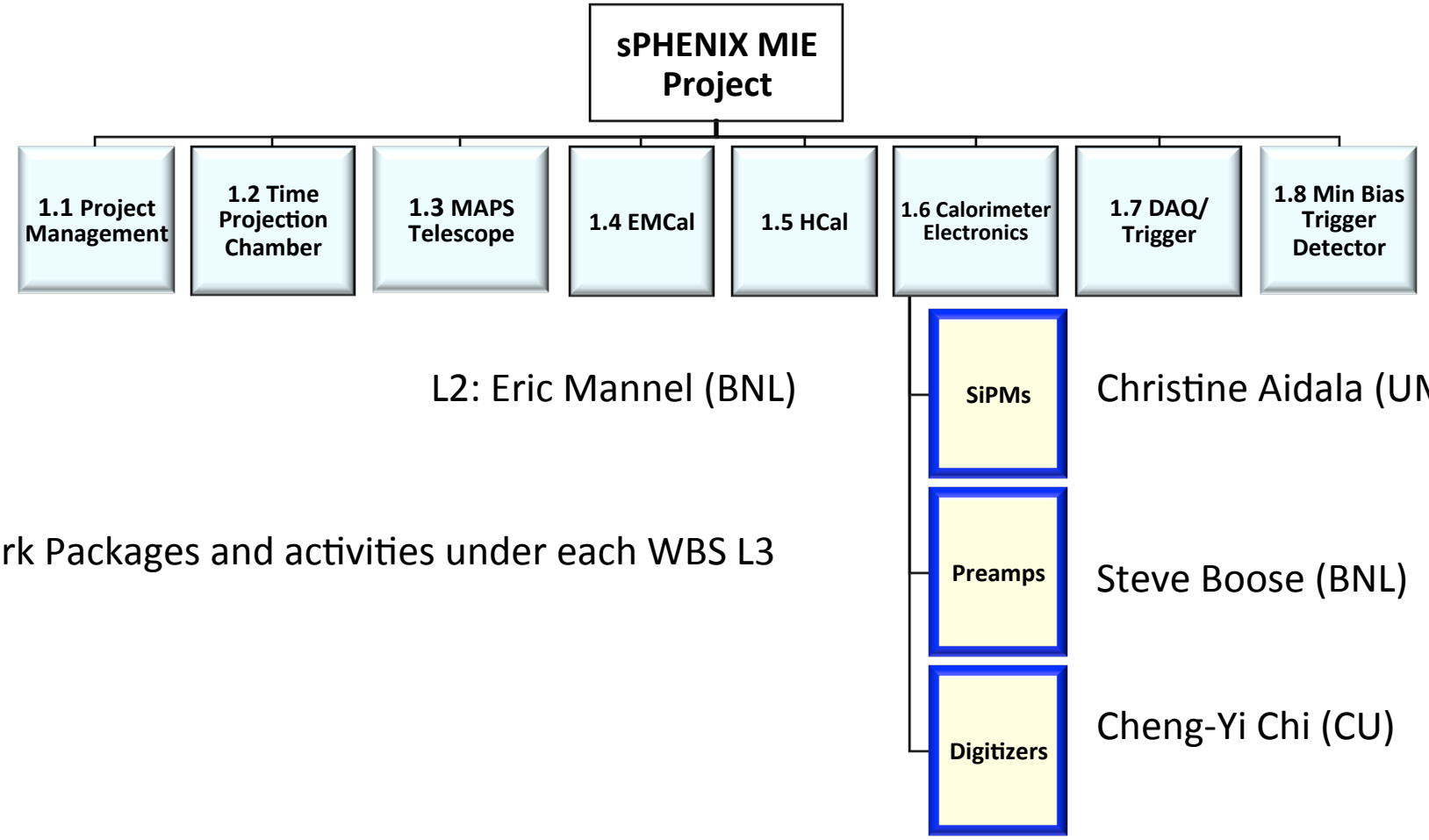
- Optical Sensors:
  - Dynamic Range: 10^4
  - Gain: 10^5
  - Photon Detection Efficiency: 25%
- Analog Front End:
  - Signal-to-Noise: 10:1
  - Peaking time: 30 nSec
  - Gain: 100 mV/pC
- Digitizer:
  - Resolution 14 bits (12 bit effective)
  - Maximum sampling frequency: 65 MHz
  - Latency (L1 Trigger): 40 Beam Crossings (BCO)
  - Multi-event buffering: 4 Events
  - L1 Trigger rate: 15 KHz

Required Number of Production Components

- Optical Sensors: 113664
  - EMCAL: 98304
  - HCal: 15360
- Preamp Boards*: 4352
  - EMCal: 1536
  - HCal: 3072
- Interface Boards*:
  - EMCal: 64
  - HCal: 128
- Controllers:
  - EMCal: 8
  - HCal: 16
- Digitizer Boards: 432
  - EMCal: 384
  - HCal: 48
- XMIT Boards:108
  - EMCal: 96
  - HCal: 12
- Digitizer Controllers/Clock Masters: 28
  - EMCal: 24
  - HCal: 4
- Crates: 28
  - EMCal: 24
  - HCal: 4

* Different layout for EMCal/HCal

C) WBS Structure and Management



D) WBS Dictionary Example

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	E. Mannel

4. WBS Element Code	5. WBS Element Title
1.07.01	Calorimeter Electronics Oversight and Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on subsystem engineer with 50% of time spent on project management.

TECHNICAL SCOPE:

Level 2 Engineer overseeing and managing the design, prototyping and production of EMCal and HCal front end and back end electronics. Responsibilities include budgeting, preparation of reports and presentations.

WORK STATEMENT:

Provide management and oversight of the design, prototyping and production of the electronics for the sPHENIX EMCal and HCal electronics. Specific tasks include:

1. Produce and monitor overall schedule for all aspects of the design, prototyping and production of the sPHENIX EMCal and HCal electronics to make sure that all milestones are met on schedule.
2. Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX EMCal and HCal electronics
3. Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX.
4. Participate in project reviews:
   a. Assist with producing review documents.
   b. Make presentations at project reviews when requested.
5. Organize and schedule technical design, prototype performance and production readiness reviews for the sPHENIX EMCal and HCal electronics.

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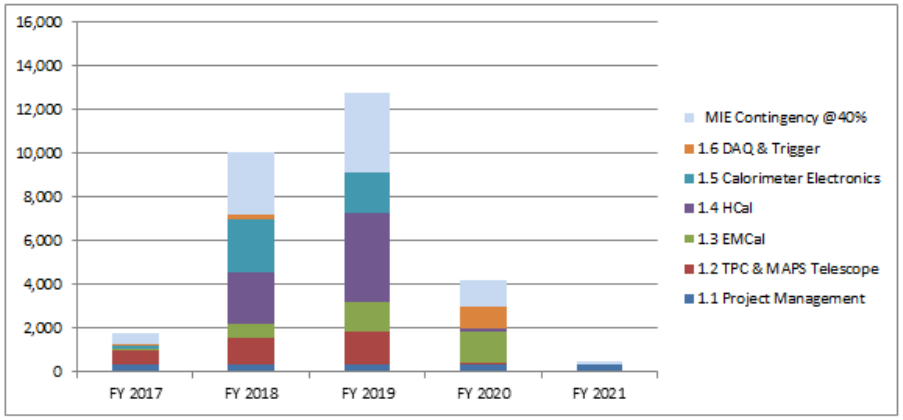
- WBS dictionary has been developed to level 4; 1.05.xxx.yyy
- Includes:
  - Cost Content
  - Technical Scope
  - Work Statement
- It is a work in progress
  - Currently ~34 tasks
  - 28 pages in length

E) Cost Estimates

- Based on:
  - Number of modules required in reference design.
  - Cost of R&D modules scaled to production quantities where possible
  - Cost of similar or past produced modules if there is not yet an R&D version.
  - Budgetary estimates for large cost items: SiPMs, FPGAs, ADCs, Signal Cables…
  - Fabrication and assembly commercially done, only final assembly done in house.
  - Includes Q/A testing
  - Continuing to refine as designs become more detailed.

E) Current Status of Cost Estimate

Category A: sPHENIX MIE Project Scope - Nov 2016



Baseline Scenario

AY k$'s - with Extraordinary Construction Overhead Application (PM Labor in Ops Support)

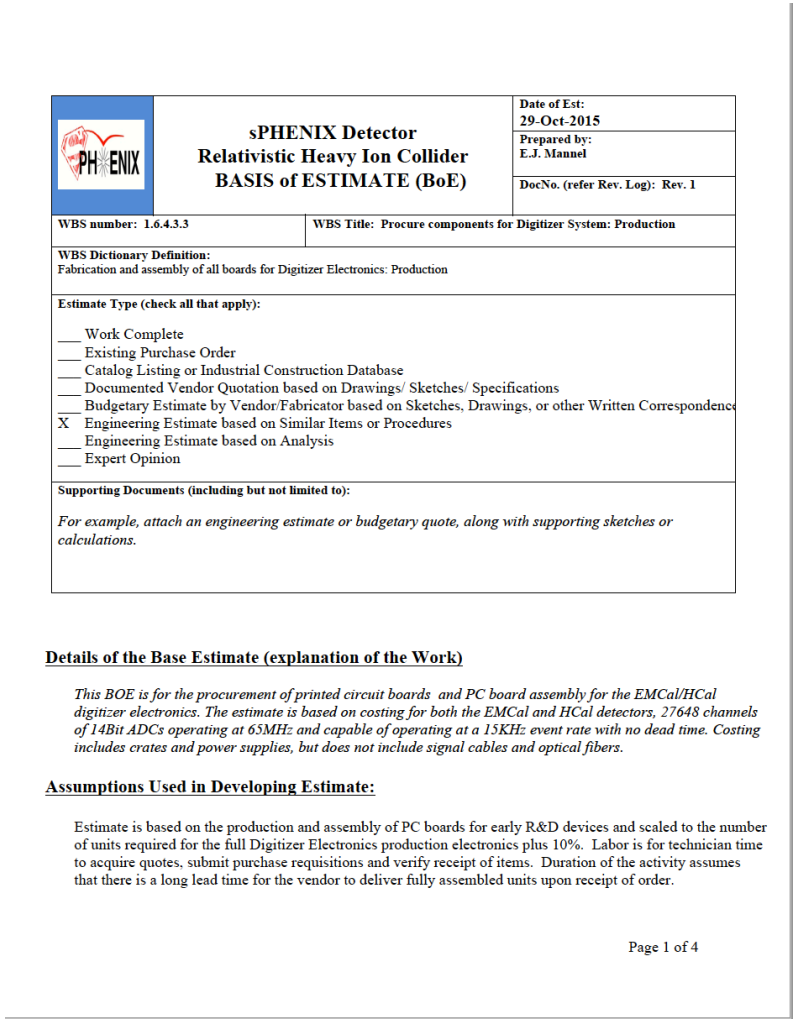
WBS	SYSTEM	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	Total
1.1	Project Management	370	370	370	370	370	1,850
1.2	TPC & MAPS Telescope	582	1,172	1,449	59		3,262
1.3	EMCal	127	647	1,401	1,383	0	3,557
1.4	HCal	0	2,353	4,044	166	0	6,562
1.5	Calorimeter Electronics	120	2,444	1,837	0	0	4,401
1.6	DAQ & Trigger	80	190	29	1,026	0	1,325
	Baseline Total	1,279	7,175	9,130	3,004	370	20,957
	MIE Contingency @40%	511	2,870	3,652	1,201	148	8,383
	MIE Total	1790	10045	12781	4205	518	29339

WBS	SYSTEM	Baseline	Contingency(40%)	Total
1.1	Project Management	1,850	740	2,590
1.2	TPC and MAPS Telescope	3,262	1305	4,567
1.3	EMCal	3,557	1423	4,980
1.4	HCal	6,562	2625	9,187
1.5	Calorimeter Electronics	4,401	1760	6,161
1.6	DAQ & Trigger	1,325	530	1,855
	MIE Totals	20,957	8,383	29,339

Revised Tracker Review - Sept 2016

Basis of Estimate

- Defines
  - Scope of the Estimate
  - Pricing assumptions
  - Labor Estimates for planning purposes. Only Proj Mangt labor is incl in MIE
  - Material
  - Risk Level
- Currently created for “high cost” Items



sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)	Date of Est: 29-Oct-2015 Prepared by: E.J. Mannel DocNo. (refer Rev. Log): Rev. 1

WBS number: 1.6.4.3.3 | **WBS Title: Procure components for Digitizer System: Production**

WBS Dictionary Definition:
Fabrication and assembly of all boards for Digitizer Electronics: Production

Estimate Type (check all that apply):

___ Work Complete
___ Existing Purchase Order
___ Catalog Listing or Industrial Construction Database
___ Documented Vendor Quotation based on Drawings/ Sketches/ Specifications
___ Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence
X Engineering Estimate based on Similar Items or Procedures
___ Engineering Estimate based on Analysis
___ Expert Opinion

Supporting Documents (including but not limited to):

For example, attach an engineering estimate or budgetary quote, along with supporting sketches or calculations.

Details of the Base Estimate (explanation of the Work)

This BOE is for the procurement of printed circuit boards and PC board assembly for the EMCal/HCal digitizer electronics. The estimate is based on costing for both the EMCal and HCal detectors, 27648 channels of 14Bit ADCs operating at 65MHz and capable of operating at a 15KHz event rate with no dead time. Costing includes crates and power supplies, but does not include signal cables and optical fibers.

Assumptions Used in Developing Estimate:

Estimate is based on the production and assembly of PC boards for early R&D devices and scaled to the number of units required for the full Digitizer Electronics production electronics plus 10%. Labor is for technician time to acquire quotes, submit purchase requisitions and verify receipt of items. Duration of the activity assumes that there is a long lead time for the vendor to deliver fully assembled units upon receipt of order.

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Basis of Estimate

Cost Summary

	Material [$]	Designer [d]	Engineer [d]	Tech [d]	Physicist [d]	Student [d]
Subsystem:	**425,000**	x	x	x	x	x

Contingency

M&S Contingency Rules Applied

- **M5**
- *Pricing based on costs for producing R&D devices of similar design and scaled for large quantities. All components are catalog items.*

Labor Contingency Rules Applied

-
- *Labor is for producing order specification documents, tracking order and verifying delivery of components*

Comments:

Provide any additional details that may affect scope, effort, materials, estimating technique, sketches, calculations, etc.

Risk Analysis: – (To Be Completed by Subsystem Manager)

- Schedule Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
  - Potential problem:
  - Mitigation:
- Cost Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
  - Potential problem:
  - Mitigation:
- Technical/Scope Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
  - Potential problem:
  - Mitigation:

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Digitizers System

Digitizer Board Fabrication	200.00	428	$85,600
Digitizer Board Assembly	600.00	428	$256,800
Controller Board Fabrication	200.00	28	$5,600
Controller Board Assembly	600.00	28	$16,800
XMIT Board Fabrication	200.00	28	$5,600
XMIT Board Assembly	600.00	28	$16,800

Cost by WBS Line:

1.6.4.3.3	$426,000.00

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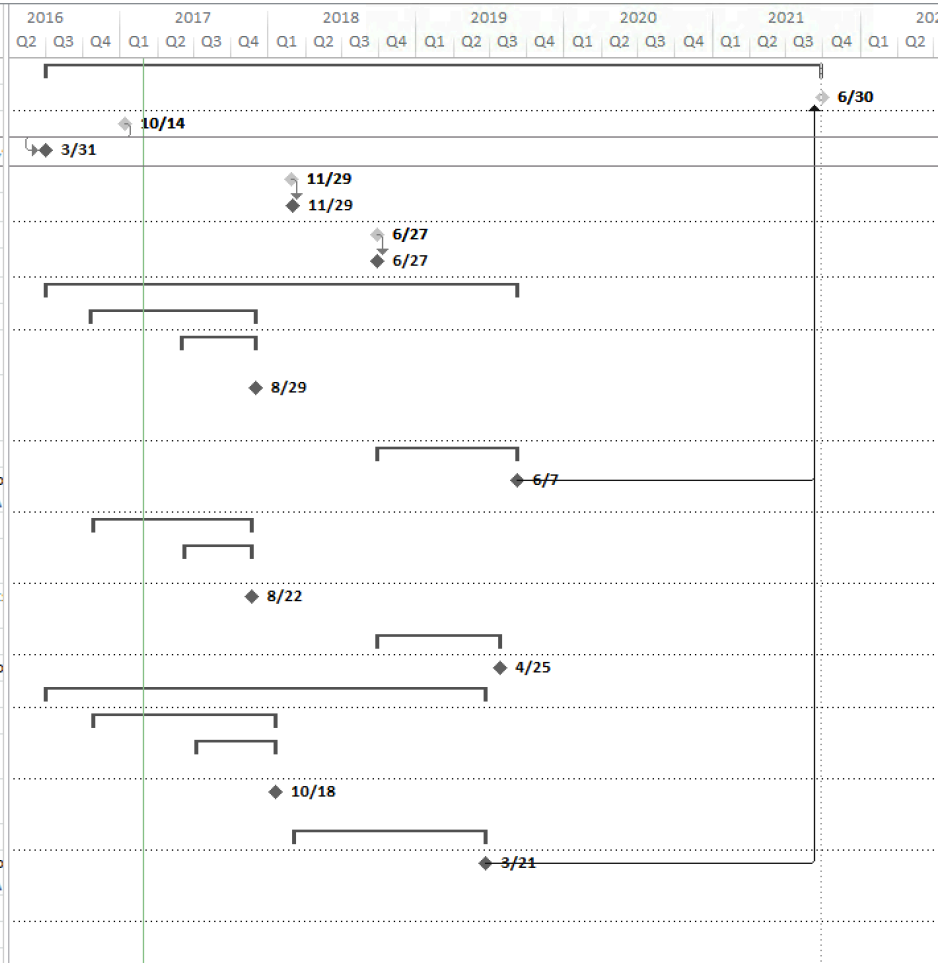
Milestones

	WBS	Task Name	Predecessors	Successors
1	**1.5.1**	**CalElectronics Management**		
3	1.10.04.07.12	Complete Commissioning	2,4,5,6,100,197	
7	1.1.2	Receive DOE CD-0 Authorization		8FS-137 days
8	1.5.1.6	SiPM choice confirmed by beam test	C:\Users\phoncs\Docum	15,32,52,102,156,2,
9	1.1.5	Receive CD-1 Authorization		10
10	1.5.1.7	Receive DOE CD-1	C:\Users\phoncs\Docum	28
11	1.1.9	Receive CD2/CD3 Authorization		12
12	1.5.1.8	Receive DOE CD-2/3	C:\Users\phoncs\Docum	47,94,146,194
50	**1.5.3**	**Calorimeter on detector electronics**		
79	**1.5.3.2**	**EMCal on detector electronics prototype**		
85	**1.5.3.2.2**	**EMCal on detector prototype electronics preproduction prototype**		
92	1.5.3.2.2.6	EMCal on-detector electronics Preproduction Prototype Testing Complete	91	70
93	**1.5.3.3**	**EMCal on detector electronics production**		
100	1.5.3.3.6	All On Detector Electronics Complete	98	C:\Users\phoncs\Do & Installation.mpp\
126	**1.5.3.5**	**HCal on detector electronics prototyping**		
134	**1.5.3.5.2**	**HCal on detector electronics preproduction prototype**		
143	1.5.3.5.2.7	Hcal on Detector electronics preproduction prototype complete	142	118,C:\Users\phonc
145	**1.5.3.6**	**HCal on detector electronics production**		
152	1.5.3.6.6	Hcal on-detector electronics complete	151,147	C:\Users\phoncs\Do
154	**1.5.4**	**Calorimeter digitizer system**		
178	**1.5.4.2**	**Calorimeter Digitizer prototype**		
184	**1.5.4.2.2**	**Calorimeter digitizer preproduction prototype**		
191		Calorimeter digitizer electronics R&D complete	190	193
192	**1.5.4.3**	**Calorimeter digitizer production**		
197	1.5.4.3.5	Complete Calorimeter Electronics	196FS+20 days	C:\Users\phoncs\Do & Installation.mpp\

GANTT CHART



H) Path to CD-1

- Updates to:
  - 1-Feb-2017: Project File; E. Mannel
  - 1-Feb-2017: WBS Dictionary; E. Mannel
  - 1-Feb-2017: Risk Analysis; E. Mannel
  - 1-Mar-2017: Bottoms up cost estimate with budgetary quotes were appropriate for most recent design. S. Stoll, C. Chi, S. Boose
  - 1-Mar-2017: Basis of Estimate and Cost Sheets; E. Mannel, S. Stoll, C. Chi, S. Boose
- Ongoing: Update design documentation
  - Technical specifications; E. Mannel, S. Boose
  - Design documents; E. Mannel, S. Boose, C. Chi
- Prepare CD-1 documentation as required; E. Mannel, S. Boose, C. Chi, C. Aidala
  - BNL Internal Review: April 2017
  - DOE Review: June 1